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Automatic quantification of handwriting characteristics before and after rehabilitation

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AIM

The aim of this paper is to present a system able to analyse handwriting movements produced by children presenting dysgraphia, submitted to a rehabilitation treatment (Terzi's method). The movements were segmented and analysed extracting a series of static and kinematic parameters, in order to measure the efficacy of the method.

INTRODUCTION

Handwriting is a specific motor task in which the movement is realized by following a precise spatio-temporal sequence. In this process particular care must be placed both in the correct automation of each grapheme and in the ergonomic aspect of the posture.

Dysgraphia, representing a learning disability resulting from the difficulty in expressing thoughts in writing, refers to the poor handwriting that can be found in primary school children.

Recently, digitizing tablets allowed objective quantitative kinematic analyses of the writing quality in children [1], in elderly subjects [2] and in Parkinson's disease [3].

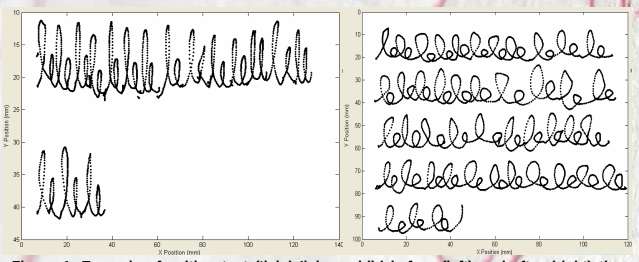

Figure 1. Example of writing test ('lelele') in a child before (left) and after (right) the rehabilitation program. In both cases the subject wrote for one minute.

RESULTS AND DISCUSSION

In Figure 1 is evident that after the treatment the total number of written letters is more than doubled as well as the corresponding curvilinear velocity (Fig. 2).

Moreover, after rehabilitation, the motor planning is different than before, presenting higher velocity minima (Fig.2) producing a more strokes programming overlapping thus demonstrating a higher automation of the motor action.

The realized system permits to quantify these modifications. In particular a significant increase of the mean velocity during single stroke ($p<0.02$) and the mean width of a stroke ($p<0.02$) were pointed out (Fig.3). At an individual level, the majority of subjects showed a significant ($p<0.02$) velocity increment in the stroke production corresponding to the substitution of the old motor program with another more automated, ables to produce a more fluent tract. However, three out of the fourteen children, after the treatment, showed a little velocity reduction (Fig.3) that is compatible with the hypothesis that these children require a longer time for consolidate the new motor programs, still not at all automated.

Moreover, an increment of the mean pressure calculated on each stroke ($p<0.001$) was generally found (Fig.4) that does not correspond to an excessive muscular tone rather to a passage from a muscular hypotonicity with a fluttering tract to a more checked pressure determining greater accuracy in the production of the graphic tract.

CONCLUSIONS

The results, confirming previous preliminary findings [6], demonstrate the potential of the realized system that supplies quantitative spatio-temporal measures of handwriting performance. The kinematic analysis of handwriting not only provides important information about the processes and strategies involved in learning and controlling handwriting but also constitutes a useful support for monitoring progress during the treatment of dysgraphia. In particular, the specific application of the system reported in this study suggests that the application of the Terzi's rehabilitation method improves the graphomotor patterns of the letter especially increasing the stroke speed of children initially identified as having poor handwriting quality.

METHODS

The handwriting of 14 non-proficient handwriters children (aged 9-12 years) attending primary school studies were acquired, by means a digitizing tablet (temporal resolution: 10ms; spatial resolution: 0.01 mm).

The execution of a simple writing exercise, consisting of a one-minute continuous sequence of 'lelele', was required (Fig.1), before and after a rehabilitation program. This was based on a cognitive-motor methodology (Terzi's approach [4]) that permits to develop the ability to obtain aware of the spatio-temporal information in order to correctly process and integrate them for a conscious use of the body during movement. All children undergo the treatment for at least 15 sessions of 45' each.

A previous developed user-friendly device [5] was used and further developed for the analysis of handwriting data both in spatial and time domains.

The movements were segmented and the strokes were identified between two successive minima in the curvilinear velocity (Fig. 2). In order to measure the treatment efficacy and to evaluate what parameters are more sensitive to the recovery process, a series of static and kinematic parameters linked to pressure, trajectory and velocity features of each stroke were calculated.

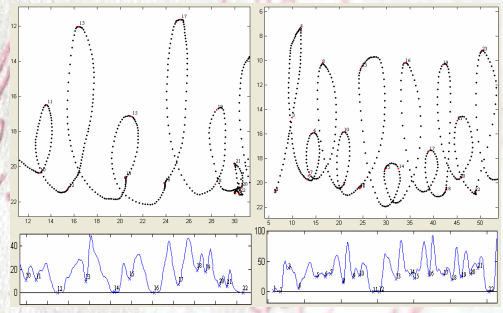

Figure 2. Top: Examples of some strokes identification in the writing of Fig.1, before (left) and after (right) the treatment. The starting point of each stroke is progressively numbered. The horizontal and vertical scales are in mm.
Bottom: Curvilinear velocity profiles corresponding to the top x-y spatial tracts. The numbering is the same of the top panels. Horizontal scale: 1 tick= ½ s; vertical scale in mm/s.

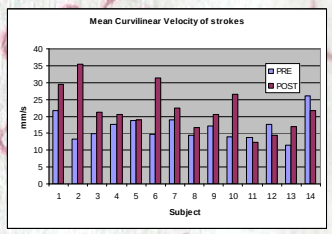

Figure 3. Mean curvilinear velocity of strokes in the considered children before (PRE) and after (POST) the rehabilitation treatment. Generally the velocity significantly increased, in a subject unchanged and in three children decreased.

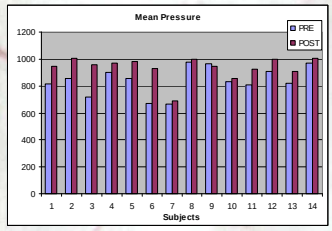

Figure 4. Mean pressure values in the children before (PRE) and after (POST) the rehabilitation treatment. Only in five cases the pressure remains about unchanged.

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REFERENCES

1. Rosenblum S, Chevion D, Weiss PL (2006) Using data visualization and signal processing to characterize the handwriting process. Pediatric Rehabil. 4:404-17
2. Rosenblum S, Werner P (2006) Assessing the handwriting process in healthy elderly persons using a computerized system, Aging Clin Exp Res. 18(5):433-9
3. Tucha O, Mecklinger L, Thome J et al (2006) Kinematic analysis of dopaminergic effects on skilled handwriting movements in Parkinson's disease. J Neural Transm. 113(5):609-23
4. Terzi I (1995) Il Metodo Spazio-Temporale. Ed. Ghedini, Milano, Italy
5. Accardo A., Chiap A., Borean M. et al (2007) A device for quantitative kinematic analysis of children's handwriting movements. Proceed of MEDICON, Lublijana 26-30 june 2007, 445-8
6. Bravar L, Borean M, Zin R, et al. (2005) Use of a graphic tablet in the evaluation of handwriting skills, before and after a movement-based treatment, in a group of children with dysgraphia. 6th Int. Conf. on Develop. Coord. Disorder (DCD), Trieste, Italy, May 17-20